VERSION OF APPLICATION WITH MARKINGS TO SHOW CHANGES MADE

SI01-012

#7

OPTICAL COUPLING DEVICE

Priority Applications

[0001] This Application claims the benefit of priority under 35 U.S.C. §119 of German Patent Application No. 19934183.4, filed July 21, 1999, and is a national stage filing under 35 U.S.C. §371 of PCT Application No. PCT/DE00/02395, filed July 21, 2000.

Field of the Invention

[0002] The invention relates to an optical coupling device for injecting light between two optical-waveguide end faces, it being possible to vary the geometrical position of the one optical-waveguide end face, for example, an optical fiber, with respect to the other optical-waveguide end face, for example a fiber-optic chip, with the aid of a variable-length element which, via a holding device, carries the one of the two optical waveguides, and is fastened to the other optical waveguide through two holding blocks.

Background of the Invention

[0003] An optical coupling device is known, for example, from WO 98/13718. Such coupling devices are used in optical filters according to the phased-array principle with an injection face, which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical filter. Optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength-multiplex operation (WDM), since they have a low input attenuation and high crosstalk suppression. The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region.

[0004] German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be established through the position of an injection optical waveguide, which guides the light into the optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the injection optical waveguide or the injection fiber. Since it is therefore desirable for the optical waveguides to be shifted relative to one another, the optical waveguides cannot be adhesively bonded directly to one another.

Summary of the Invention

[0005] In the optical coupling device [cited] described in the [introduction] Field of the Invention, the holding blocks are fastened to the chip, and the optical fiber is held on the variable-length element. In this case, the variable-length element may oscillate or bend, which causes temporary or permanent deadjustment of the fiber, even though a certain degree of guiding is provided.

[0006] It is therefore an object of the invention to ensure improved guiding of the variable-length element parallel to its extension direction and to avoid deadjustment during operation.

Brief Description of the Drawing

[0007] FIG. 1 illustrates a side view of an exemplary embodiment of the Invention

Detailed Description of the Invention

[0008] The [To achieve this object, the] optical coupling device mentioned in the introduction is embodied [characterized] in that the variable-length element, or the holding element [device], is held by a spring element, which is spongily or porously designed and which is supported directly or indirectly on at least one of the holding blocks and allows movements of the variable-length element, or the holding element [device], in the length direction of the variable-length element, in which the variable-length element is extended or shortened, and prevents movement of the variable-length element perpendicular to the length direction of the variable-length element. The variable-length element, which is necessarily fastened further away to the other optical waveguide, that is to say the planar waveguide [chip], presses against the holding element [device] for the fiber, in order to permit the relative movement of the fiber with respect to the planar waveguide [chip]. The spring element is configured in such a way that residual movement perpendicular to the plane is maximally suppressed. The effect achieved by this is that the movement of the fiber relative to the chip takes place very exactly parallel to the chip face and virtually no deadjustment perpendicular thereto occurs.

[0009] Since the spring element is spongily or porously designed and the wall thickness of the spring element is hence reduced in comparison with the wall thickness of the solid material, the desired elasticity or spring characteristic is imparted to the spring element. Through selection of the ratio between the remaining wall thickness and the hole size, it is advantageously possible to vary the elasticity in wide ranges.

[0010] In the invention, it is furthermore advantageous that the holding block can be adhesively bonded to the second optical waveguide (optical-waveguide chip, also known in

the art as a planar waveguide) very close to the fiber, so that large levers are avoided. Undesired movements in the directions perpendicular to the desired extension of the variable-length element are thereby reduced significantly.

[0011] An advantageous configuration of the coupling device according to the invention is [characterized in] that the variable-length element, the holding element [device] and the spring element are arranged between the two holding blocks, and in that the holding element [device] is designed integrally with the variable-length element and the spring element is designed separately therefrom. In this case, it is advantageous that the material of the spring element can be selected without having to take into account the requirements placed on the material of the variable-length element.

[0012] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the variable-length element, the holding element [device] and the spring element are arranged between the two holding blocks, and in that the holding element [device], the variable-length element and the spring element are designed integrally. This configuration has production-technology advantages and also has advantages relating to the operational reliability and the life of the arrangement.

[0013] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the variable-length element, the holding element [device] and the spring element are arranged between the two holding blocks, and in that the holding element [device] and the spring element are designed integrally and the variable-length element is designed separately therefrom. Here again, it is possible to produce the holding elements [devices] and the spring element without having to pay attention to the material of the variable-length element.

[0014] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the variable-length element, the holding element [device] and the spring element are arranged between the two holding blocks, and in that the holding element [device], the spring element and the holding block connected thereto are designed integrally and the variable-length element is designed separately therefrom.

[0015] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the spring element is formed by slots in the variable-length element, or the holding element [device], which lie in a plane parallel to the end faces and perpendicular to the length direction of the variable-length element. These slots can be employed particularly advantageously whenever the variable-length element, the holding

element [device] and the spring element, or alternatively at least the holding element [device] and the spring element, are designed integrally with one another. The direction of the slots is also advantageous since, if the slots are rotated through 90°, for example, stability in the critical direction perpendicular to the chip plane is no longer sufficiently guaranteed.

[0016] Another advantageous configuration of the coupling device according to the invention is [characterized in] that an even number of slots is provided. Tilting tendencies can thereby be minimized.

[0017] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the spring element is formed by bores in the variable-length element, or the holding element [device], which lie in a plane parallel to the end faces and perpendicular to the length direction of the variable-length element. Such bores are easy to machine-produce, it being possible to set the spring constant of the spring element through the size of the bores.

[0018] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the length of the variable-length element is selected in such a way that the spring element is under prestress in the starting position of the variable-length element. This guarantees that, if it is designed separately from the variable-length element, the holding element [device] follows the variable-length element when the latter contracts.

[0019] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the two holding blocks are connected to one another by a link, the arrangement consisting of the two holding blocks, the variable-length element, the holding element [device] and the spring element being provided with greater stability.

[0020] Another advantageous configuration of the coupling device according to the invention is [characterized in] that the two holding blocks are connected to one another by a frame, a respective link being provided at the top and at the bottom between the two holding blocks, and the links being produced in one piece with the holding blocks, so that they can be adhesively bonded with the latter to the chip.

[0021] Lastly, another advantageous configuration of the coupling device according to the invention is [characterized in] that the holding element [device] has a ferrule in which the optical waveguide, or the optical fiber, is fastened. It would admittedly also be possible to fasten the fiber to the resilient element without a ferrule, for example by adhesive bonding in a V-groove. Nevertheless, it is preferable to use a ferrule owing to the accuracy of the fit and

the avoidance of aging phenomena in the adhesive for adhesively bonding the fiber in the V-groove.

[0022] An exemplary embodiment of the invention will be described with the aid of the appended drawing, FIG. 1, which shows a side view of the exemplary embodiment of the coupling device according to the invention.

[0023] FIG.1 [The figure] shows a side view of a coupling device according to an exemplary embodiment of the invention, in which two holding blocks 4, 6 (the first and second holding blocks, respectively) are fastened, for example adhesively bonded, on an optical-waveguide chip 2. The first holding block [One of the holding blocks] 4 carries a variable-length element 8. An optical fibre [A fiber] 10 is fastened to a holding element [device]12. The variable-length element 8 is clamped or adhesively bonded between the one holding block 4 and a holding element [part] 12 for the fiber 10.

[0024] The variable-length element 8, or the holding element [part] 12, is supported on the holding block 6 via a spring element 14. The spring element is formed by outer slots 16 and inner slots 18. The slots 16, 18 can also be replaced by bores. In the vicinity of the spring element 14, the material may also be spongily or porously designed.

[0025] For the spring element 14, it is only necessary for the wall thickness of the spring element to be reduced in comparison with the wall thickness of the solid material, in order to impart the desired elasticity or spring characteristic to the spring element 14. Through selection of the ratio between the remaining wall thickness and the hole size, it is possible to vary the elasticity in wide ranges.

[0026] In the exemplary embodiment that is shown, the two holding blocks 4, 6 are connected to one another via a link 20, which lies in the plane of the fiber-optic chip 2. The two holding blocks 4, 6 can also be connected to one another via a frame, which stands perpendicular to the face of the fiber-optic chip 2, which ensures that the coupling device overall is stabilized. In this exemplary embodiment, the links can be produced in one piece or adhesively bonded to one another.

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[Patent Claims]

1. [An optical coupling device for injecting light between two optical-waveguide end faces, it being possible to vary the geometrical position of the one optical-waveguide end face, for example an optical fiber, with respect to the other optical-waveguide end face, for example a fiber-optic chip, with the aid of a variable-length element which, via a holding device, carries the one of the two optical waveguides, and is fastened to the other optical waveguide through a holding block, characterized in that the variable-length element (8), or the holding device (12), is held by a spring element (14), the spring element (14) is spongily or porously designed and is supported directly or indirectly on at least one of the holding blocks (4, 6) and allows movements of the variable-length element, or the holding device, in the length direction of the variable-length element, in which the variable-length element is extended or shortened, and prevents movement of the variable-length element perpendicular to the length direction of the variable-length element.]

2. [The device as claimed in claim 1, characterized in that the variable-length element (8), the holding device and the spring element (6) are arranged between the two holding blocks (4, 6), and in that the holding device is designed integrally with the variable-length element and the spring element is designed separately therefrom.]

3. [The device as claimed in claim 1, characterized in that the variable-length element (8), the holding device and the spring element are arranged between the two holding blocks (4, 6), and in that the holding device, the variable-length element and the spring element are designed integrally.]

4. [The device as claimed in claim 1, characterized in that the variable-length element (8), the holding device (12) and the spring element (14) are arranged between the two holding blocks (4, 6), and in that the holding device and the spring element are designed integrally and the variable-length element is designed separately therefrom.]

5. [The device as claimed in claim 1, characterized in that the variable-length element (8), the holding device (12) and the spring element (14) are arranged between the two holding blocks (4, 6), and in that the holding device, the spring element and the holding block (6) connected thereto are designed integrally and the variable-length element is designed separately therefrom.]

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6. [The device as claimed in one of claims 1 to 5, characterized in that the spring element (14) is formed by slots (16, 18) in the variable-length element (8), or the holding device, which lie in a plane perpendicular to the length direction of the variable-length element, the open edges lying perpendicular to the chip plane.]

7. [The device as claimed in claim 6, characterized in that an even number of slots are provided.]

8. [The device as claimed in one of claims 1 to 5, characterized in that the spring element (14) is formed by bores in the variable-length element (8), or the holding device, which lie in a plane parallel to the end faces of the optical waveguides and perpendicular to the length direction of the variable-length element.

9. [The device as claimed in one of the preceding claims, characterized in that the length of the variable-length element is selected in such a way that the spring element is under prestress in the starting position of the variable-length element.]

10. [The device as claimed in one of the preceding claims, characterized in that the two holding blocks (4, 6) are connected to one another by a link (20).]

11. [The device as claimed in claim 1, characterized in that the two holding blocks are connected to one another by a frame, a respective link being provided at the top and at the bottom between the two holding blocks.]

12. [The device as claimed in one of the preceding claims, characterized in that the holding device is a ferrule in which the optical waveguide (10), or the optical fiber, is fastened.]

1. An optical coupling device for injecting light between end faces of two optical waveguides, said device comprising:

a first and second holding block;

a first and second optical waveguide, wherein the first of waid waveguides is an optical fiber and the second of said waveguides is a waveguide chip, and each of waid waveguides has an end face;

a holding element for holding said first optical waveguide;

a spring element supported in said first holding block;, and

an elongate variable-length element;

wherein said variable-length element is supported on said first holding block and its length is paralleled to the face of the second optical waveguide, and said variable-length element ends in contact with said holding element such that it is possible to vary the geometrical position of the first optical waveguide with respect to the second optical waveguide; and

wherein the spring element is positioned between the holding element attached to said variable-length element and the second holding block, and is supported on said second holding block, said spring element having the form of a spongy or porous body having holes selected from the group consisting of slots and bores extending perpendicular to the length direction of the variable-length element and paralleled to the end face of the second waveguide.

[(2, 10), having a holding device for holding the one optical waveguide (10), a holding block (4) which is fitted on the other optical waveguide (2), an elongate variable-length element (8) which is supported on the one holding block (4) and extends in its length direction, starting from the one holding block (4), parallel to the end face of the other optical waveguide (2) and on which the holding device is provided, so that it is possible to vary the geometrical position of the end face of the one optical waveguide (10), for example an optical fiber, with respect to the end face of the other optical waveguide (2), for example a fiber-optic chip, another holding block (6) which is arranged, with respect to the length direction of the variable-length element (8), on the side thereof remote from the one holding block (4), and a spring element (14) which is arranged between the variable-length element (8) and the other holding block (6) and is supported thereon, and on which the variable-length element (8) with the holding device provided thereon is held, characterized in that the spring element (14) is designed in the form of a spongy or porous body having holes extending perpendicular to the length direction of the variable-length element (8) and parallel to the end face of the other optical waveguide (2).]

2. The device as claimed in claim 1, wherein [characterized in that] the holding element [device] is designed integrally with the variable-length element [(8)]and the spring element [(14)] is designed separately therefrom.

3. The device as claimed in claim 1, wherein [characterized that] the holding element [device], the variable-length element [(8)] and the spring element [(14)] are designed integrally.

4. The device as claimed in claim 1, wherein [characterized in that] the holding element [device] and the spring element [(14)] are designed integrally and the variable-length element [(8)] is designed separately therefrom.

5. The device as claimed in claim 1, wherein [characterized in that] the holding element [device], the spring element [(14)] and the holding block [(6)] connected thereto are designed integrally and the variable-length element [(8)] is designed separately therefrom.

6. The device as claimed in Claim1, wherein the number of slots or bores is an even number.

7 [6]. The device as claimed in claim 1, wherein [one of claims 1 to 5, characterized in that] the spring element [(14)] is formed by slots [(16, 18)] in the variable-length element [(8)], or the holding element [device].

8. The device as claimed in claim 2, wherein the spring element is formed by slots in the variable-length element, or the holding element.

9 The device as claimed in claim 3, wherein the spring element is formed by slots in the variable-length element, or the holding element.

[7. The device as claimed in claim 6, characterized in that an even number or slots or bores is provided.]

10. [8.] The device as claimed in claim 1, wherein [one of claims 1 to 5, characterized in that] the spring element [(14)] is formed by bores in the variable-length element [(8)], or the holding element [device].

11. The device as claimed in claim 2, wherein the spring element is formed by bores in the variable-length element , or the holding element.

12. The device as claimed in claim 3, wherein the spring element is formed by bores in the variable-length element , or the holding element.

13. [9.] The device as claimed in claim1, wherein [one of the preceding claims, characterized in that] the length of the variable-length element [(8) is selected in such a way that the spring element [(14)] is under prestress in the starting position of the variable-length element [(8)].

14. [10.] The device as claimed in claim 1, wherein [one of the preceding claims, characterized in that] the two holding blocks [(4, 6)] are connected to one another by a link [(20)].

15. [11.] The device as claimed in claim 1, characterized in that the two holding blocks [(4, 6)] are connected to one another by a frame, a respective link being provided at the top and at the bottom between the two holding blocks [(4, 6)].

16. [12.] The device as claimed in claim 1, wherein [one of the preceding claims, characterized in that] the holding element [device] is or contains a ferrule in which the optical waveguide [(10)], or the optical fiber, is fastened.

Abstract

Optical coupling device

An optical coupling device for injecting light between two optical-waveguide end faces, in which the geometrical position of the one optical-waveguide end face with respect to the other optical-waveguide end face can be varied with the aid of a variable-length element. The element carries one of the two optical waveguides, and is fastened to the other optical waveguide through a holding block. The variable-length element is held by a spring element, which is spongily or porously designed and which is supported directly or indirectly on at least one of the holding blocks and allows movements of the variable-length element in the length direction of the variable-length element, in which the variable-length element is extended or shortened, and prevents movement of the variable-length element perpendicular to the length direction of the variable-length element. The spring element is spongily or porously designed.

[Figure 1]